Nuclear and Particle Physics Directorate

Strategic Planning Retreat

Operations

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70 YEARS OF DISCOVERY

A CENTURY OF SERVICE

U.S. DEPARTMENT OF ENERGY

BROOKHAVEN NATIONAL LABORATORY

Overview/Scope of Work: Operations

1. ESSHQ
   - Safe and environmentally sound accelerator operations
2. Support & Maintain C-AD Projects & Operations (RHIC, NSRL, BLIP, etc.)
   - Engineering for operations and upgrades (LEReC, SRF, ATF, ATF-II, CeC, etc.)
   - Facility & Experimental support (+ cranes, shops, safety equipment, etc.)
   - Power Supplies and Electrical Distribution
   - Injectors & Pre-injectors operations & maintenance
   - Controls, Communications, Cryo, Instrumentation, RF, & Vacuum
3. 24/7 operations management and support
4. Presently the successful operations of RHIC depends on many key pieces of equipment and systems, some of which have been in operation for almost 5 decades.

Internal strengths related to Operations

1. ESSHQ
   - Experienced personnel in accelerator safety, environmental protection, conduct of operations, QA; Reputation: 30 years of reducing injury rates, reducing occurrence rates and reducing environmental impacts while growing safe and efficient C-AD operations
2. Engineering
   - Staff engineering experience in operations & systems design, design tools, and experienced technical support team
   - Technical support shops with tools and equipment to troubleshoot, repair, assemble, and test equipment
3. Facility & Experiment Support
   - Significant experience and “know-how” exists in executing experimental projects at the engineering and technical levels. Examples are detector assembly, coil building, shielding assembly, sophisticated survey and metrology capability, and delicate equipment transport.
   - A workforce that is committed to and interested in working with the Scientific community.
   - Collider-Accelerator Support, group of experienced technicians provide 24/7 watch service all year long to provide response for any emergent condition
   - CAD possesses a robust and flexible infrastructure.

Internal strengths related to Operations, cont.

4. Power Supplies and Electrical Distribution
   - Technical Expertise with Equipment and In House Repair Capabilities
   - Conservative Designs and Operating Points for Equipment
   - Spare Parts Inventory
5. Injectors & Pre-injectors operations & maintenance
   - State of the art ion sources that generate world record beam intensities
   - Ion source R&D groups pushing the limits of the technology
   - International reputations with 30+ years experience
6. Controls, Communications, Cryo, Instrumentation, RF, & Vacuum
   - 30+ years of successfully designing, building, & maintaining highly reliable systems
   - International reputation; members on science advisory, international executive, & project review committees
   - Design & development of state of the art systems that have been employed to successfully operate RHIC and RHIC pre-injector systems
   - E.g., design & develop state of the art timing systems, machine protection systems, personnel protection systems, all digital high performance control and feedback systems, eLens, Stochastic Cooling, & specialized systems such as the NASA Galactic Cosmic Ray simulator and BLIP raster scanning

Internal Weaknesses related to Operations

1. In General
   - Aging infrastructure (old buildings, old HVAC systems, old wiring) must support new systems
2. ESSHQ
   - Reliance on support organizations
3. Engineering
   - New components added with RHIC upgrades; staff not added to support new equipment.
   - Building space charges are high and do not adequately cover needed maintenance.
   - Upgrade funds for facility minimal and cost to upgrade is high. Only 2 new labs in 16 years.
   - Support staff aging, minimum funding for new hires. Usually, only limited replacement has been allowed. Assignments have to be split among other workers.
   - Paperwork and training from outside entities with little understanding of C-AD operations.
4. Facility & Experiment Support
   - Keeping pace with new technologies. E.g., new lasers require more precise conditions
   - As systems grow and evolve to provide greater capabilities, existing buildings & utility services must accommodate more equipment, increasing the power and cooling loads.

Internal Weaknesses related to Operations, cont.

4. Power Supplies and Electrical Distribution
   - Aging workforce and the possibility of losing technical expertise
   - Ever increasing number of sophisticated systems with shrinking manpower base
   - Lack of resources (time, money, manpower) to properly maintain or upgrade equipment
   - Upgrading systems will require removing older equipment significant downtime
   - New installations must comply with newer more restrictive codes.
   - Updating the power distribution system is very costly in terms of material, installation, and power outages.
5. Injectors & Pre-injectors operations & maintenance
   - Systems as much as 47 yrs old. High Power RF tubes (7835) has single supplier.
6. Controls, Communications, Cryo, Instrumentation, RF, & Vacuum
   - Aging Infrastructure: VME systems > 15 yrs old, unavailable parts for existing designs, network fiber beyond end of life, RHIC cryo refrigerator nearing 40 yrs old
   - Keeping pace with technology: data management and growth, cyber security, proliferation of Internet capable devices, keeping up with new project demands
   - Staffing: aging workforce, unable to replace people who leave, more work to do than people to do it.

External Opportunities: Operations

1. ESSHQ
   - reductions in unnecessary ESH requirements and unnecessary ESSHQ assessments
2. Engineering, Facility & Experiment Support
   - Many new opportunities with new projects, such as CBETA, sPHENIX, ATF II, BLIP, and eRHIC R&D; however, expected to use existing C-AD engineering already assigned to other projects.
   - LEReC – 2 years of RHIC operations with new equipment and new ways of operating (high intensity low energy electron beams). Matrixed staffing with some staffing removed for other projects before this project is done. New systems needed with new support staff (lasers, cathodes, HV power supplies, operational SCRF cavities).
   - Most external interactions demand more resources either from a technical perspective or from an overhead, reporting or compliance perspective.

External Opportunities: Operations, cont.

3. Power Supplies and Electrical Distribution
   - Benefit from upgrades at other Laboratories such as the replacement of the MG Set at CERN
   - Upgrading the Booster power supply would reduce energy costs and probably remove the operational constraints caused by its interaction with the utility.
   - Keep in close contact with other Accelerator Laboratory Specialists such as the POCPA group(Power Converters for Particle Accelerators)
   - Newer power Equipment can reduce arc flash hazards and increase worker safety.
   - New installations add redundancy to distribution systems, allow easier troubleshooting and repair.

4. Injectors & Pre-injectors operations & maintenance
   - Planned upgrades for EBIS, LINAC, & BLIP (2nd User line)
   - Collaborations with BINP, RIKEN, KEK, Tokyo IT, Nagaoka Univ., Utsunomiya Univ., Doshisha Univ., IPM, Messina Univ., CERN, MIT
   - Tandem van de Graff users: 15 users including NASA, GE, ASC, & other companies

5. Controls, Communications, Cryo, Instrumentation, RF, & Vacuum
   - Greater collaboration with NSLS II and other labs (GSI, CERN, FNAL, etc.)
   - Greater communication with other labs = more innovation
   - Open Hardware Initiative = better designs and improved cost effectiveness

External Threats: Operations

1. ESSHQ
   - Moving ESH back to external staff from ESH Directorate; ESH roles at C-AD will change from implementing ESH programs and solving problems and return to advising on ESH programs and pointing out problems
2. Engineering
   - Lack of funding or insufficient funding.
   - Staff expected to multitask on multiple projects (each projects is the highest priority).
3. Facility & Experiment Support
   - An increasing amount of regulatory, reporting and other overhead burdens (project management, training and documentation, etc.) decreases percentage of productive technical work hours available per FTE.
   - Lack of funds to hire technical staff in advance of retirements to support succession planning.
   - Competition for scientific facilities and engineering expertise from other laboratories and companies
   - Potential funding shortfalls/reductions
   - Increasingly stringent codes (Building, Fire, Mechanical and Electrical) require significant upgrades to systems and structures in order to keep them operating
   - Technical talent becoming increasingly scarce in the New York/Long Island area. If this trend continues, it will be increasingly difficult to address the remaining challenges that we face.

External Threats: Operations, cont.

4. Power Supplies and Electrical Distribution
   - External expertise for some older technologies is disappearing.
   - Older power equipment is more likely to fail causing downtime and was designed without regard to arc flash concerns.
5. Injectors & Pre-injectors operations & maintenance
   - Lack or insufficient funding
6. Controls, Communications, Cryo, Instrumentation, RF, & Vacuum
   - Expertise in computer technologies is moving away from traditional systems used in the control systems (today, more cloud & web)
   - Expertise in specialized systems in high demand (e.g., network engineering) or more scarce (e.g., RF and Vacuum engineers)
   - Engineers need to stay abreast of current technology and trends. Retaining high quality engineers is challenging.
   - Training takes significant time: > 10 years to become an expert. Need to have (substantial) incentives to retain people.
   - Radiation upsets in Alcove equipment
   - Competition for resources between projects (e.g., CeC and LEReC)

Goals: Operations

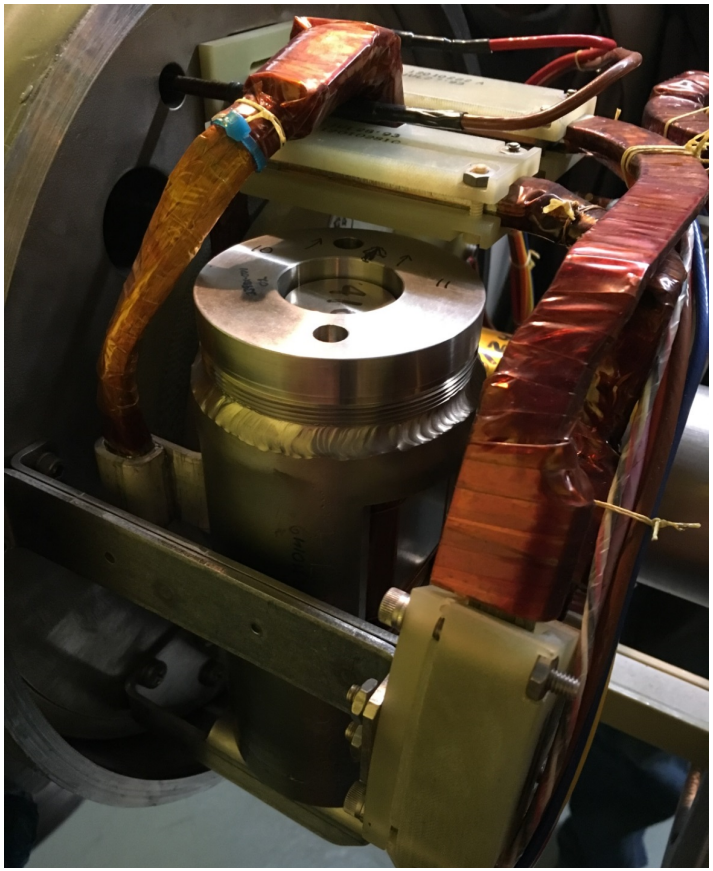
1. ESSHQ
   - Short term: authorization bases for LEReC, polarized eGun, and CO2 laser
   - Longer term: reductions in injuries and events, reduction in emissions from BLIP, authorization bases for sPHENIX and ATF II
2. Engineering
   - Short term: Keep RHIC running safely & efficiently and keep RHIC upgrade programs moving
   - Long term: Orderly transition of equipment and responsibilities due to staff turnover.
3. Facility & Experiment Support
   - Increase the engineering and technical capabilities of our people by obtaining more modern tools (both software and hardware) and providing the training to use them effectively.
   - Convince others of the value of streamlining processes and relieving compliance burden while still delivering effective and safe services.

Goals: Operations, cont.

4. Power Supplies and Electrical Distribution
   - Replace older power distribution equipment as resources allow.
   - Install new systems with arc flash concerns addressed in the design stage
   - Retire older systems before they become obsolete and replace them with modern equipment. This means retiring equipment which is still functioning.
   - Hire new employees to learn the intricacies of our equipment before system experts retire.
5. Injectors & Pre-injectors operations & maintenance
   - Short term: EBIS/LINAC upgrades, expand Tandem user base
   - Long term: 2nd BLIP line, LINAC with newer technologies
6. Controls, Communications, Cryo, Instrumentation, RF, & Vacuum
   - Short term: meet year to year performance goals & maintain high availability of systems
   - Long term: improve recoverability and failover systems and develop tractable data management systems and tools

Key Concerns: Operations

1. In General
   - Aging Infrastructure & Aging Workforce
   - Increasing regulatory demands
   - Maintaining a high level of support and product quality under dwindling budgets, greater project demands, and continually increasing oversight
2. ESSHQ
   - Going from the best ESSHQ performance to a mediocre level of ESSHQ performance
3. Power Supplies and Electrical Distribution
   - Arc flash concerns with older power distribution equipment
   - Underground cabling to the Accelerator Facilities
   - The cost and time to do major upgrades to such critical systems as:
     - Cabling within the AGS
     - Booster Main Magnet Power Supply
     - Lack of External Support for the MG sets
     - Lifetime of the RHIC bypass diode
4. Controls, Communications, Cryo, Instrumentation, RF, & Vacuum
   - Resources needed to pursue technologies that can improve efficiency and streamline operations



RHIC Bypass Diode Failure

Underground Cable

Failed Cable

Old MCC Build 929

New MCC Building 929

Control Systems Overview

Parameter	Value
Number of front-end systems	520
Number of read/write parameters (settings)	663,985
Number of read-only parameters (measurements)	907,162
Number of name server entries (devices & servers)	75,128
Number of All control points in the system	1,567,147
Total Data Stored (1998 – present)	>450 TB (~1.65 PB uncompressed)
Total Amount of Data written to disk in Run 17	~120 TB compressed
# of applications & servers (C++ and Java)	815
Number of lines of computer code	> 5 Million
Number of system servers (machines)	168

Accelerator Data – Stored Data/Year